NIWA
Taihoro Nukurangi

Report on the 2011 assessment of Pacific sardine

Prepared for The Center for Independent Experts
Northern Taiga Ventures, Inc.

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Reviewed by

Andrew McKenzie

Approved for release by

Dr Julie Hall

Executive summary

A STAR Panel met 4-7 October 2011 at the Southwest Fisheries Science Center in La Jolla, California to review the 2011 draft assessment of Pacific sardine. The assessment, and some additional analyses, were presented and discussed. Some modifications to the assessment were agreed to, and the Panel wrote its report.

I conclude that the modified assessment, though characterised by a high degree of uncertainty, constitutes the best available science. The analytic methodology used was generally sound but methods of data weighting could be improved. The review process was excellently run.

With regard to data weighting I recommend consideration be given to

- adopting the approach proposed by Francis (2011) in future assessments, and
- improving the Stock Synthesis documentation related to this topic.

To reduce uncertainty in future assessments I recommend particular attention be paid to

- reducing relative bias in age estimates,
- producing priors on survey catchabilities, and
- resolving uncertainty about survey selectivities.

For future assessments I also recommend that

- age compositions be used, rather than the combination of length compositions and conditional age-at-length data,
- the methodology of the Canadian trawl survey be reviewed so that these data might be used if found suitable,
- an attempt be made to reduce the lack of model fit for older fish, and
- in considering whether to change model structural assumptions concerning sex and the number of fisheries, the STAT be cautious about unnecessarily complicating the model structure.

For future CIE reviews I recommend that attention be given to the way that Statements of Work specify the structure of the reviewer's report.

1 Background

This report reviews, at the request of the Center for Independent Experts (see Appendix 2), the 2011 assessment of the stock of Pacific sardine (*Sardinops sagax*) which is fished off the west coast of North America, from northern Mexico to Canada. The author was provided with various documents (Appendix 1), and participated both in the meeting which considered the assessment, and in the writing of the Panel Report from that meeting.

2 Review activities

The stock assessment review (STAR) Panel met 4-7 October 2011 at the Southwest Fisheries Science Center of NOAA/NMFS in La Jolla, California. Those attending the meeting included four Panel members, three representatives of the Pacific Fishery Management Council (PFMC), the teams responsible for the stock assessment and associated surveys, and other interested parties from both the fishing industry and the research community (Appendix 3). The assessment and related material were presented to the Panel, and numerous additional analyses requested by the Panel were carried out and discussed. The Panel, in consultation with the STAT (the stock assessment team), agreed on some modifications to the assessment, and further analyses were carried out to evaluate the modified assessment. The Panel drafted their report.

3 Summary of findings

For reasons given below (in Section 3.6), neither this section nor the next is structured according to the Terms of Reference for the review, as was required by my Statement of Work (Appendix 1). Instead, I have grouped my findings in a way that seemed natural.

3.1 Best available science

I believe that the Pacific sardine assessment, as produced by the STAT, with some modifications developed during the STAR Panel meeting, constitutes the best available science, and does a reasonable job of estimating the status of the stock and quantifying the considerable uncertainty about that status. The assessment used state of the art software (Stock Synthesis), which was applied professionally and diligently by the STAT.

Much of the uncertainty in this assessment stems from the fact that, although it is relatively data-rich, it is still information-poor. In particular, although four separate time series of abundance were available (Total Egg Production [TEP], Daily Egg Production Method [DEPM], trawl-acoustic, and aerial) these were not in agreement about biomass trends.

One consequence of this uncertainty was that the assessment model was quite unstable. That is, small changes in the data or model assumptions sometimes produced large changes in estimated stock status. This instability imposed a considerable constraint on both the STAT and the STAR Panel by making the process of evaluating alternative model assumptions very time-consuming. Thus some possible model improvements could not be evaluated in the time available. In particular it was not possible to seek model configurations that better fitted the abundance time series.

3.2 Analytic methodology

The analytic methodology used in this assessment – implemented in Stock Synthesis (Methot 2005, 2011) – followed standards that have been established in other assessments within the PFMC jurisdiction. I believe Stock Synthesis to be excellent software, which has been thoroughly tested and is widely used – both within and outside the PFMC jurisdiction.

In general I approve of the standard methodology, but I think there is one aspect that could be improved in the next assessment: data weighting.

3.2.1 Data weighting

Stock assessment results are often sensitive to the weight (or emphasis) given to different data sets. A data set can be given more weight by decreasing coefficients of variation (c.v.s) (in the case of abundance data) or increasing effective sample sizes (in the case of age or length composition data). The approach I suggest considering for the next assessment is that proposed by Francis (2011). I will not repeat the arguments advanced in that paper, but will discuss two components of the proposed approach in the context of the sardine assessment, and then make some comments about data weighting in Stock Synthesis.

The first component is the need to down-weight length and/or age composition data to account for correlations. A useful way to illustrate this need is to plot observed and expected mean lengths (or ages), as is done in Figure 1 for the length composition data in the draft base model. The fact that the expected mean lengths in this plot are often outside the confidence intervals for the observations indicates that the length composition data were over-weighted. Down-weighting these data (by decreasing the multinomial sample sizes) would increase the width of the plotted confidence intervals.

Most methods of iteratively reweighting composition data (including that used in Stock Synthesis) implicitly assume that the residuals associated with one length (or age) bin are uncorrelated with those from another bin. In fact, correlations between composition residuals are often strong, and show a characteristic pattern like that in Figure 2.

Francis (2011) suggested that one way to avoid over-weighting composition data is to base the re-weighting calculation on the residuals of mean length (or age), rather than on residuals of individual proportions. Application of this approach to the length composition data in the base model suggested that the multinomial sample sizes for these data should be smaller by a factor of 0.06 – 0.1 (Table 1).

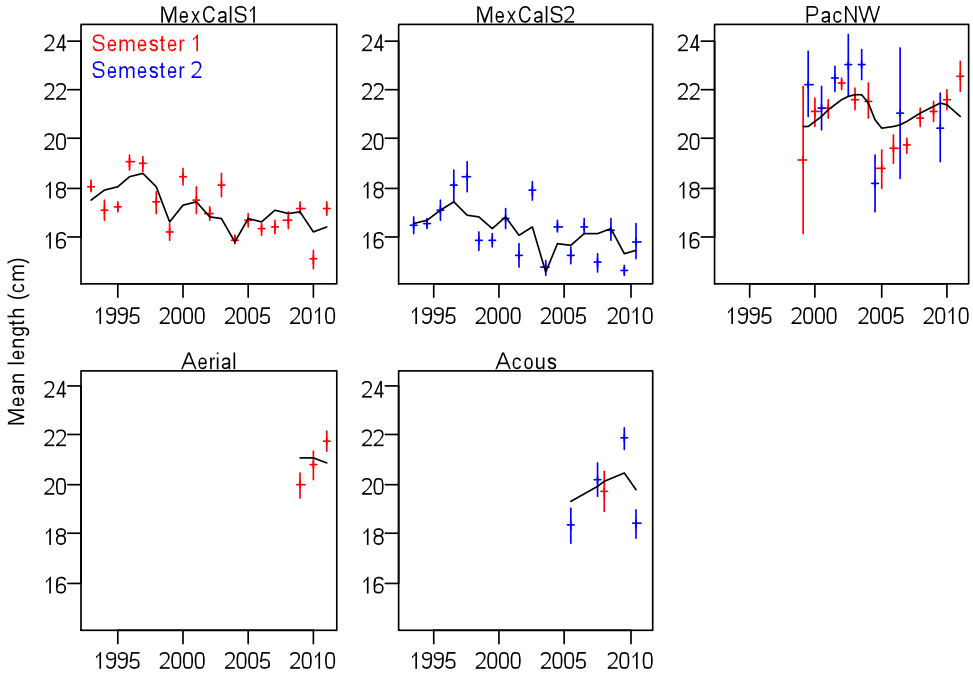

Figure 1: Observed ('+') and expected (lines) mean lengths for all length composition data in the base model. Confidence intervals (shown as vertical lines) were calculated using the multinomial sample sizes assumed for the base model (i.e., the products of the initial sample sizes and effN_mult_Lencomp values in tables 4 and 9 of Hill et al. 2011).

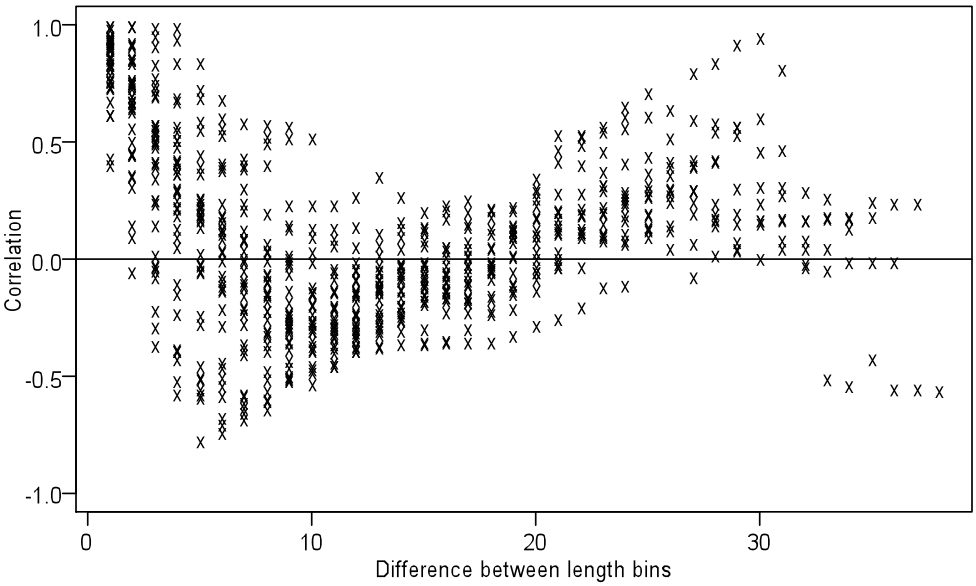

Figure 2: Correlations amongst residuals from the MexCal_S1 length composition data in the base model. Each plotted point represents a correlation between the vectors of residuals for two length bins; the x-axis shows the distance (number of bins) between the two length bins.

Table 1: Suggested reweighting of the length composition data from the base model in the draft assessment report (Hill et al. 2011). The suggested sample sizes, N_new, are the product of the sample sizes assumed in the base model, N_base, and a multiplier, N multiplier.

Data set	Median N_base	N_multiplier[1]	Median N_new
MexCalS1	135.9	0.058	7.9
MexCalS2	117.7	0.061	7.2
PacNW	40.9	0.104	4.3
Aerial	14.8	0.067[2]	1.0
Acous	43.5	0.067[2]	2.9

[1]Calculated using method TA1.8 of Francis (2011, Appendix A, in which N_multiplier is denoted w_j)
[2] Because of small sample sizes (i.e., few years of observations), the N_multiplier for the aerial and acoustic-trawl surveys was calculated by combing these two series

Another component of the data weighting approach proposed by Francis (2011) is the importance of fitting abundance indices well. A striking feature of both the draft and final assessments was that none of the four abundance indices was well fitted. One possible reason for this is that the three indices that overlap (DEPM, trawl-acoustic, and aerial) show quite different trends. All indicate that the biomass dropped substantially, but they disagree about the years over which this occurred (2004-2007 for DEPM; 2005-2009 for trawl-acoustic; and 2009-2010 for aerial). Schnute & Hilborn (1993) pointed out that when two data sets are contradictory it is a mistake to include both in an assessment model. It is better to consider two alternative assessments: one without the first data set, and one without the second. If there are no grounds for preferring one data set over the other then the difference between the two alternative assessments serves as a measure of the uncertainty about stock status. In jurisdictions in which a STAT is required to provide only one assessment they will be forced to choose which of two contradictory data sets is more plausible. One fact in support of choosing the trawl-acoustic survey is its similarity in trend to the Canadian trawl survey (see Section 3.4.2 below).

Sometimes the year-to-year changes in an abundance index are so large that the index cannot be well fitted by any plausible model. In this case, the appropriate response is to discard the index, on the grounds that it cannot be representative of the population. This might be the case with the TEP index, which jumped up by a factor of almost 4 in 1999, and then dropped by a factor of more than 5 over the next 2 years. I wonder if the spawning biomass of sardines can change so rapidly.

Finally, I offer some comments on the iterative reweighting of abundance indices as is commonly done (including in this assessment) with Stock Synthesis. This involves adding to the initial survey standard errors (labelled 'S.E. ln(index)' in table 5 of Hill et al. 2011), variance adjustment terms (labelled 'index_extra_cv' in table 9 of Hill et al. 2011) which have been calculated from an earlier model run without any variance adjustment. This approach has the apparent merit of being objective, but Francis (2011) argued that full objectivity is not possible in data weighting. A perverse consequence of this approach in the sardine assessment was that it assigned slightly more weight to TEP than to DEPM (the median final standard errors for the two series were 0.62 and 0.66, respectively), even though the consensus of attendees at the STAR Panel seemed to be that DEPM was likely to be superior to TEP as an index of spawning biomass (that consensus opinion – partly subjective – was not used in the stock assessment). I note also that I could not find in the Stock

Synthesis documentation provided (Methot 2005,2011) either a description of how these variance adjustments were calculated, or a justification for simply adding them to the initial standard errors (the conventional approach is to sum standard errors as squares: $s.e.[final]^2 = s.e.[initial]^2 + s.e.[extra]^2$). My attempts to replicate the calculation of the variance adjustments, using what seemed to me to be the appropriate approach, were not successful. Whatever the method of calculation, it cannot be considered very reliable because it is analogous to estimating a variance from a very small sample (sample sizes [i.e., numbers of years] were 8, 9, 3, and 5 for the DEPM, TEP, aerial, and trawl-acoustic surveys, respectively).

3.3 Sources of uncertainty

Two types of factor contributed to the uncertainty in this assessment: those that were largely unavoidable; and those that are potentially reducible.

Some important unavoidable factors are the wide area traversed by this stock (from northern Mexico to Canada); the substantial movements (both ontogenetic and annual) that it undertakes; and the fact that the nature and extent of these movements (primarily north-south, but also inshore-offshore) will vary from year to year in a way that is inherently difficult to measure. A consequence of these factors is that there may be substantial variation in the portion of the stock that is vulnerable to capture or sampling (either by the fishery or by surveys) at a given place and time. This variation is likely to be responsible for much of the year-to-year changes in mean lengths (and ages) in the fishery catches, and possibly also in the survey samples (see Figure 1). It also leads to uncertainty about the extent to which we can be sure that each survey is indexing the same portion of the population in each year.

Potentially reducible sources of uncertainty include sampling error (e.g., survey c.v.s), stock structure, ageing error, and survey catchabilities (*q*s) and selectivities. It is obviously sensible to try to reduce uncertainty from all these sources, but I think special emphasis should be given to the last three, which I now discuss in turn.

3.3.1 Ageing error

In my view ageing error could well be a serious problem for this assessment, and my concern is more with (relative) bias, than with precision. Between-reader bias was sometimes very substantial (see plots labelled 'Age bias plot' in Dorval et al. 2011), to the point that I wondered how bad such bias would need to be before the age estimates were deemed unusable in the stock assessment. I don't mean to imply incompetence on the part of age readers. Some species' otoliths are inherently very difficult to read, and Pacific sardine appears to be one such species. However, I am aware that the consistency of ageing has been significantly improved for *some* species by the development of strict ageing protocols and regular inter-agency comparisons. This is not a simple task, and it will not be achieved quickly.

3.3.2 Survey catchabilities

There are three approaches to dealing with survey catchabilities (commonly referred to as *q*s) in stock assessment models. First, we can tell the model we know nothing about the catchabilities, as was done for all surveys in the draft assessment. Because the survey biomass indices showed no consistent trends, this approach made the model unstable in terms of absolute biomass. That is, slightly different model configurations sometimes

estimated biomass trajectories that were similar in trend, but greatly different in level. In order to reduce this type of instability the STAR Panel meeting decided to adopt a second approach – for the trawl-acoustic survey alone – which was to tell the model that catchability was known exactly (it was fixed to 1). I approve of this decision as a short-term measure, because it will tend to reduce year-to-year changes in stock status (and in particular, in the estimate of current 1+ biomass, which is important for management purposes). However, I recommend that the third approach, which is intermediate between the first two, be adopted for future assessments if possible. This is to provide the model with a summary of what is known about each survey catchability in the form of a prior distribution for this parameter.

I note that the task of generating survey catchability priors should not be the responsibility of the STAT. This task is often addressed by the combination of a Bayesian statistician (whose expertise relates to the function of a prior distribution in a model) and subject experts (the survey teams, whose expertise is in understanding all the factors that contribute to catchability for their type of survey [e.g., target strength for acoustic surveys, proportion spawning for egg surveys, etc]). In Bayesian parlance the statistician is said to 'elicit' the prior from the experts.

3.3.3 Survey selectivities

The assessment model was unable to fit the considerable year-to-year changes in length compositions for both the trawl-acoustic and aerial surveys. There was a similar problem with age compositions for the acoustic survey.

There are three alternative explanations for this lack of fit. One possibility is that the survey selectivity is changing substantially from year to year. This would be of concern because it would undermine the value of these surveys, since they would be surveying a substantially different portion of the population each year.

In both of the other two explanations the survey selectivity does not vary significantly from year to year, but there are different reasons for the lack of fit. One reason would be that the composition data from these surveys were not representative of the portion of the population being surveyed. This would be of concern because it would mean that the survey selectivity was poorly estimated in the assessment. Thus, in fitting the survey biomass index the observed biomass would be compared by the model to the wrong expected biomass. Alternatively, it could be that the composition data *are* representative, but the model has estimated the wrong parameters (particularly those for growth and recruitment). It may be that with different parameter values the model would achieve a much better fit to the survey composition data.

This last explanation may be correct for the aerial surveys, where an upward trend in mean length is consistent with a similar trend from the catches in the PacNW fishery (in a similar area), and neither trend was fitted by the model (see Figure 1). An upward trend in mean length suggests the population in that area is dominated by one or more year classes. This could be checked if the otoliths from the aerial survey were aged.

3.4 Model data and structure

3.4.1 Use of age and length data

Both age and length composition data were available for most years for the three fisheries (MexCal in semesters 1 and 2, and PacNW), and for three of the five years for the trawl-acoustic survey. I suggest that it is a mistake in this situation to include both the length composition (LC) and the conditional age-at-length data (CA@L) in the model. It is better to include just the age compositions (ACs), omitting the other data types.

I acknowledge that this suggestion is counter-intuitive. It seems obvious that there is more information in the combination of LC and CA@L, than there is in AC alone. While this is true in general, it is *not* true for the type of model used in this assessment, because this model is age-structured. That is to say, the model's accounting system is age-based: it reconstructs the history of the sardine population by keeping track of the number of fish of each age in each time step in each year. The model deals with length data (and with selectivities that are functions of length) only by converting back and forth between length and age, using its growth parameters. In particular, to calculate a likelihood for an observed LC the model converts its expected AC to an expected LC using information about the relationship between length and age that is contained in its growth parameters. The problem is that these growth parameters are the same for all years and all areas, whereas we know, from the CA@L data that the relationship between length and age varies, both from year to year, and from south to north. Thus, it is better to use the time and area-varying information we have in the CA@L data to convert our LCs to ACs outside the model, and then to include only these ACs in the model.

3.4.2 Canadian survey

The 2009 STAR Panel recommended that the fishery-independent mid-water trawl survey series off the west coast of Vancouver Island should be considered for inclusion in the current assessment. The STAT rightly argued that this series would be of limited utility because of (*inter alia*) very high c.v.s (1.5 – 3.0). During the STAR Panel meeting a Canadian representative reported that there had been an error in the calculation of these c.v.s, and the correct values were much smaller (0.23 – 0.39 [see Appendix 3 of the STAR Panel report]).

Another important characteristic of this survey, not noticed during the STAR Panel meeting (at least by me), is that it estimates a biomass trend very similar to that from the U.S. trawl-acoustic survey (Figure 3). Since these surveys were carried out independently, and in different areas, this similarity in trend provides strong support to both surveys as being representative of actual changes in the sardine population.

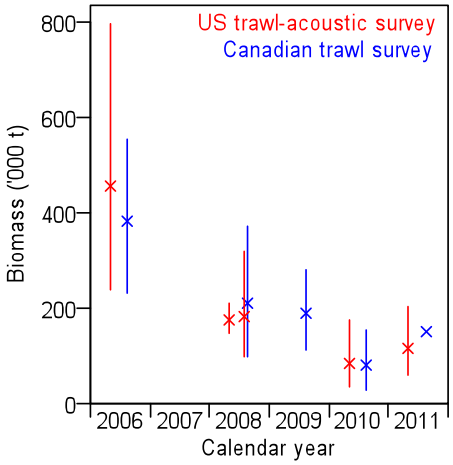

Figure 3: Comparison of biomass estimates from Canadian trawl surveys and US trawl-acoustic surveys. To aid comparison the US estimates have been scaled to have the same mean as the Canadian ones. Vertical bars are 95% confidence intervals.

3.4.3 Lack of fit to old fish

A systematic lack of fit to the conditional age-at-length data indicated that fewer old fish were observed – in surveys and catches – than was expected by the model. This lack of fit is most easily seen in the plots of residuals to the implied age frequencies: most of the residuals for the older age classes were negative. As a consequence, a profile on natural mortality, M, had its minimum at $M = 0.625$ y^{-1}: higher than was considered plausible, and much higher than the value assumed in the assessment ($M = 0.4$ y^{-1}).

It would be good to try to remove this systematic lack of fit in future assessments. This might be done by introducing age-dependent natural mortality, or changing the form of the selectivities. The danger is that the model might compromise the fit to the abundance indices in an attempt to find combinations of parameters that slightly reduce the lack of fit at older ages.

3.4.4 Sex and fishery structure

During the STAR Panel meeting, evidence emerged that suggested that two of the STAT's decisions on model structure – to ignore sex, and to have only two fisheries – may need to be reconsidered. Proportion female in fishery catches was shown to exceed 0.5 in bigger fish, and female spawning biomass was estimated to be more than half of total spawning biomass in 7 of the 8 DEPM surveys. Also, splitting the length composition data from the two model fisheries showed that Canadian fish tended to be larger than those from Oregon and Washington, and Mexican fish were larger than those from California.

I support the suggestion that these structural decisions be reconsidered, but urge caution. Changes to these structures will increase model complexity (and parameter numbers), and increased complexity makes it harder for the modeller to understand what is driving the model. I point out that the aim of stock assessment modelling is to inform fishery management, not to build the most realistic model possible.

For example, consider the decision as to whether to include sex in the model. The evidence cited above makes it clear that including sex would make the model more realistic. But realism isn't the point. I suggest the questions to ask are (a) does including sex materially change the estimated stock status? and (b) if so, is the change in estimated status plausible? Sex should be included in the model only if the answers to both questions are 'yes'. If in doubt, err on the side of simplicity.

3.5 Review process

The review process was excellently run by PFMC, with support from SWFSC staff. Before the meeting I was particularly aware of contributions from Kerry Griffin, Nancy Lo, and Jennifer McDaniell, and of course Kevin Hill, who lead the considerable effort required to get the draft assessment report ready in time. I was especially pleased to see the Stock Synthesis input files included in this report because that allowed me to check on some of the technical details that can be important. During the meeting, both the STAT and survey teams went out of their way to respond to queries and requests from the Panel. The Panel was very ably chaired, and all participants showed a constructive approach to the review.

3.6 Terms of Reference

The present review raised a problem that I think needs to be considered when Statements of Work (SOWs) are prepared for future reviews. The problem concerns the Terms of Reference (ToRs) within the SOW (Appendix 1).

These ToRs were used in two distinct ways within the SOW. The first way, which posed no problems for me, was to direct the activities of the CIE reviewer before (ToR 1) and during (ToRs 2-6) the review meeting (e.g., on p. 3 of the SOW: "The CIE reviewer shall … participate in … the meeting review panel, and … shall be focused on the ToRs …"). The second way was to structure the CIE reviewer's report (e.g., Annex 1 of the SOW says the report shall include "Summary of Findings for each ToR", and this is underlined under **Acceptable Performance Standards** where it says "the CIE report shall address each ToR").

This latter use of the ToRs has not been a problem for me in previous reviews because the ToRs for those reviews have referred to aspects of the assessment being reviewed (e.g., "Comment on quality of data used in the assessment" and "Evaluate and comment on analytic methodologies"). However, the ToRs in the present SOW refer to activities of the panel members, rather than aspects of the assessment. It would not make sense for me to include in my report findings for each of these ToRs. For example, ToR 2 is "Working with STAT Teams to ensure assessments are reviewed as needed", and ToR 3 is "Documenting meeting discussions". If I were to present findings related to these ToRs I would be reviewing the panel activities rather than the sardine assessment.

I discussed this problem with Manoj Shivlani (CIE) before the review meeting and he agreed that, for this review, I need not take literally the requirement to structure my report around the ToRs.

4 Conclusions and recommendations

4.1 Best available science

I conclude that the assessment, as modified during the STAR Panel meeting, constitutes the best available science.

4.2 Analytic methodology

The analytic methodology used in this assessment was generally sound but methods of data weighting could be improved.

I recommend consideration be given to

- adopting the data-weighting approach proposed by Francis (2011), and
- improving the Stock Synthesis documentation relating to data weighting.

4.3 Sources of uncertainty

This assessment was characterised by a high degree of uncertainty.

To reduce uncertainty in future assessments I recommend particular attention be paid to

- reducing relative bias in age estimates,
- producing priors on survey catchabilities, and
- resolving uncertainty about survey selectivities.

4.4 Model data and structure

For future assessments I recommend that

- age compositions be used, rather than the combination of length compositions and conditional age-at-length data,
- the methodology of the Canadian trawl survey be reviewed so that these data might be used if found suitable,
- an attempt be made to reduce the lack of model fit for older fish, and
- in considering whether to change assumptions concerning sex and the number of fisheries, the STAT be cautious about unnecessarily complicating the model structure.

4.5 Review process

The review process was excellently run, with great support from PFMC and SWFSC staff, and enthusiastic cooperation from both STAT and survey teams.

4.6 Terms of Reference

The STAR Panel's Terms of Reference were suitable for guiding the reviewer's activities during the Panel meeting, but not for structuring this report.

For future CIE reviews I recommend that attention be given to the way that Statements of Work specify the structure of the reviewer's report.

5 References

Dorval, E.; McDaniell, J.; Hill, K. (2011). An evaluation of the consistency of age-determination of Pacific sardine (*Sardinops sagax*) collected from Mexico to Canada. Appendix 2 in the draft assessment report.

Hill, K.T.; Crone, P.R.; Lo, N.C.H.; Macewicz, B.J.; Dorval, E.; McDaniel, J.D.; Gu, Y. (2011). Assessment of the Pacific sardine resource in 2011 for U.S. management in 2012. Draft assessment report.

Francis, R.I.C.C. (2011). Data weighting in statistical fisheries stock assessment models. *Canadian Journal of Fisheries and Aquatic Sciences* **68**: 1124–1138.

Methot, R.D. (2005). Technical Description of the Stock Synthesis II Assessment Program Version 1.17

Methot, R.D. (2011). User manual for Stock Synthesis model version 3.21d. Updated May 8, 2011

Schnute, J.T.; Hilborn, R. (1993). Analysis of contradictory data sources in fish stock assessment. Can. J. Fish. Aquat. Sci. 50(9): 1916–1923.

Appendix 1. Materials provided for the review

The reviewer was provided with access to the following documents on an ftp website (ftp://swfscftp.noaa.gov/users/jmcdaniel/Pacific Sardine STAR 202011/)

1. The draft assessment report (Hill et al. 2011)
2. User Manual and Technical Documentation for Stock Synthesis (Methot 2005, 2011)
3. Background documents on the three surveys series (egg, acoustic, and aerial)
4. 2011 SAFE (Stock Assessment And Fishery Evaluation) document
5. Reports from previous assessments, 2007-2010

Appendix 2. Statement of work

This appendix contains the Statement of Work that formed part of the consulting agreement between the Center for Independent Experts and the author.

External Independent Peer Review by the Center for Independent Experts

STAR Panel Review of Pacific Sardine Stock Assessment

October 4-7, 2011

Scope of Work and CIE Process: The National Marine Fisheries Service's (NMFS) Office of Science and Technology coordinates and manages a contract providing external expertise through the Center for Independent Experts (CIE) to conduct independent peer reviews of NMFS scientific projects. The Statement of Work (SoW) described herein was established by the NMFS Project Contact and Contracting Officer's Technical Representative (COTR), and reviewed by CIE for compliance with their policy for providing independent expertise that can provide impartial and independent peer review without conflicts of interest. CIE reviewers are selected by the CIE Steering Committee and CIE Coordination Team to conduct the independent peer review of NMFS science in compliance the predetermined Terms of Reference (ToRs) of the peer review. Each CIE reviewer is contracted to deliver an independent peer review report to be approved by the CIE Steering Committee and the report is to be formatted with content requirements as specified in **Annex 1**. This SoW describes the work tasks and deliverables of the CIE reviewer for conducting an independent peer review of the following NMFS project. Further information on the CIE process can be obtained from www.ciereviews.org.

Project Description: The CIE reviewer will serve on a Stock Assessment Review (STAR) Panel and will be expected to participate in the review of Pacific sardine stock assessment. The Pacific sardine stock is assessed regularly (currently, every 1-2 years) by SWFSC scientists, and the Pacific Fishery Management Council (PFMC) uses the resulting biomass estimate to establish an annual harvest guideline (quota). The stock assessment data and model are formally reviewed by a Stock Assessment Review (STAR) Panel once every three years, with a coastal pelagic species subcommittee of the SSC reviewing updates in interim years. Independent peer review is required by the PFMC review process. The STAR Panel will review draft stock assessment documents and any other pertinent information for Pacific sardine, work with the stock assessment teams to make necessary revisions, and produce a STAR Panel report for use by the PFMC and other interested persons for developing management recommendations for the fishery. The PFMC's Terms of Reference (ToRs) for the STAR Panel review are attached in **Annex 2**. The tentative agenda of the Panel review meeting is attached in **Annex 3**. Finally, a Panel summary report template is attached as **Annex 4**.

Requirements for CIE Reviewer: One CIE reviewer shall participate during a panel review meeting in La Jolla, California during 4-7 October, and shall conduct an impartial and independent peer review accordance with the SoW and ToRs herein. The CIE reviewer shall have the expertise as listed in the following descending order of importance:

- The CIE reviewer shall have expertise in the application of fish stock assessment methods, particularly, length/age-structured modeling approaches, e.g., 'forward-simulation' models (such as Stock Synthesis, SS) and it is desirable to have familiarity in 'backward-simulation' models (such as Virtual Population Analysis, VPA).
- The CIE reviewer shall have expertise in the life history strategies and population dynamics of coastal pelagic fishes.
- It is desirable for the CIE reviewer to be familiar with the design and execution of fishery-independent surveys for coastal pelagic fishes.
- It is desirable for the CIE reviewer to be familiar with the design and application of fisheries underwater acoustic technology to estimate fish abundance for stock assessment.
- It is desirable for the CIE reviewer to be familiar with the design and application of aerial surveys to estimate fish abundance for stock assessment.

The CIE reviewer's duties shall not exceed a maximum of 14 days to complete all work tasks of the peer review process.

Location/Date of Peer Review: The CIE reviewer shall conduct an independent peer review during the STAR Panel review meeting at NOAA Fisheries, Southwest Fisheries Science Center, 8604 La Jolla Shores, La Jolla, California from October 4-7, 2011.

Statement of Tasks: The CIE reviewer shall complete the following tasks in accordance with the SoW, ToRs and Schedule of Milestones and Deliverables specified herein.

Prior to the Peer Review: Upon completion of the CIE reviewer selection by the CIE Steering committee, the CIE shall provide the CIE reviewer information (name, affiliation, and contact details) to the COTR, who forwards this information to the NMFS Project Contact no later the date specified in the Schedule of Milestones and Deliverables. The CIE is responsible for providing the SoW and ToRs to the CIE reviewer. The NMFS Project Contact is responsible for providing the CIE reviewer with the background documents, reports, foreign national security clearance, and information concerning other pertinent meeting arrangements. The NMFS Project Contact is also responsible for providing the Chair a copy of the SoW in advance of the panel review meeting. Any changes to the SoW or ToRs must be made through the COTR prior to the commencement of the peer review.

Foreign National Security Clearance: When CIE reviewers participate during a panel review meeting at a government facility, the NMFS Project Contact is responsible for obtaining the Foreign National Security Clearance approval for CIE reviewers who are non-US citizens. For this reason, the CIE reviewers shall provide requested information (e.g., first and last name, contact information, gender, birth date, passport number, country of passport, travel dates, country of citizenship, country of current residence, and home country) to the NMFS Project Contact for the purpose of their security clearance, and this information shall be submitted at least 30 days before the peer review in accordance with the NOAA Deemed Export Technology Control Program NAO 207-12 regulations available at the Deemed Exports NAO website:
http://deemedexports.noaa.gov/compliance_access_control_procedures/noaa-foreign-national-registration-system.html

Pre-review Background Documents: Two weeks before the peer review, the NMFS Project Contact will send by electronic mail or make available at an FTP site to the CIE reviewer all necessary background information and reports for the peer review. In the case where the

documents need to be mailed, the NMFS Project Contact will consult with the CIE on where to send documents. The CIE reviewer shall read all documents in preparation for the peer review, for example:

- Recent stock assessment documents since 2009;
- STAR Panel- and SSC-related documents pertaining to reviews of past assessments;
- CIE-related summary reports pertaining to past assessments; and
- Miscellaneous documents, such as ToR, logistical considerations.

Pre-review documents will be provided up to two weeks before the peer review. Any delays in submission of pre-review documents for the CIE peer review will result in delays with the CIE peer review process, including a SoW modification to the schedule of milestones and deliverables. Furthermore, the CIE reviewer is responsible only for the pre-review documents that are delivered to the reviewer in accordance to the SoW scheduled deadlines specified herein.

Panel Review Meeting: The CIE reviewer shall conduct the independent peer review in accordance with the SoW and ToRs. **Modifications to the SoW and ToR cannot be made during the peer review, and any SoW or ToR modification prior to the peer review shall be approved by the COTR and CIE Lead Coordinator.** The CIE reviewer shall actively participate in a professional and respectful manner as a member of the meeting review panel, and their peer review tasks shall be focused on the ToRs as specified in the contract SoW.

Respective roles of the CIE reviewer and STAR Panel chair are described in Annex 2 (see p. 6-8). The CIE reviewer will serve a role that is equivalent to the other panelists, differing only in the fact that he/she is considered an 'external' member (i.e., outside the Pacific Fishery Management Council family and not involved in management or assessment of West Coast CPS). The CIE reviewer will serve at the behest of the STAR Panel Chair, adhering to all aspects of the PFMC's ToR as described in Annex 2. The STAR Panel chair is responsible for: 1) developing an agenda, 2) ensuring that STAR Panel members (including the CIE reviewer), and STAT Teams follow the Terms of Reference, 3) participating in the review of the assessment (along with the CIE reviewer), 4) guiding the STAR Panel (including the CIE reviewer) and STAT Team to mutually agreeable solutions.

The NMFS Project Contact is responsible for any facility arrangements (e.g., conference room for panel review meetings or teleconference arrangements). The CIE Lead Coordinator can contact the Project Contact to confirm any peer review arrangements, including the meeting facility arrangements.

Contract Deliverables - Independent CIE Peer Review Reports: The CIE reviewer shall complete an independent peer review report in accordance with the SoW. The CIE reviewer shall complete the independent peer review according to required format and content as described in Annex 1. The CIE reviewer shall complete the independent peer review addressing each ToR as described in Annex 2.

Other Tasks – Contribution to Summary Report: The CIE reviewer will assist the Chair of the panel review meeting with contributions to the Summary Report. The CIE reviewer is not required to reach a consensus, and should instead provide a brief summary of their views on the summary of findings and conclusions reached by the review panel in accordance with the ToRs.

Specific Tasks for CIE Reviewer: The following chronological list of tasks shall be completed by the CIE reviewer in a timely manner as specified in the **Schedule of Milestones and Deliverables**.

1) Conduct necessary pre-review preparations, including the review of background material and reports provided by the NMFS Project Contact in advance of the peer review;
2) Participate during the panel review meeting in La Jolla, California during October 4-7, 2011 as called for in the SoW, and conduct an independent peer review in accordance with the ToRs (Annex 2);
3) No later than October 21, 2011, the CIE reviewer shall submit an independent peer review report addressed to the "Center for Independent Experts," and sent to Mr. Manoj Shivlani, CIE Lead Coordinator, via email to shivlanim@bellsouth.net, and Dr. David Die, CIE Regional Coordinator, via email to ddie@rsmas.miami.edu. The CIE report shall be written using the format and content requirements specified in Annex 1, and address each ToR in Annex 2.

Schedule of Milestones and Deliverables: CIE shall complete the tasks and deliverables described in this SoW in accordance with the following schedule.

August 22, 2011	CIE sends reviewer contact information to the COTR, who then sends this to the NMFS Project Contact
September 20, 2011	NMFS Project Contact sends the CIE Reviewer the pre-review documents
October 4-7, 2011	The reviewer participates and conducts an independent peer review during the panel review meeting
October 21, 2011	CIE reviewer submits draft CIE independent peer review reports to the CIE Lead Coordinator and CIE Regional Coordinator
November 4, 2011	CIE submits CIE independent peer review reports to the COTR
November 11, 2011	The COTR distributes the final CIE reports to the NMFS Project Contact and regional Center Director

Modifications to the Statement of Work: Requests to modify this SoW must be made through the Contracting Officer's Technical Representative (COTR) who submits the modification for approval to the Contracting Officer at least 15 working days prior to making any permanent substitutions. The Contracting Officer will notify the CIE within 10 working days after receipt of all required information of the decision on substitutions. The COTR can approve changes to the milestone dates, list of pre-review documents, and Terms of Reference (ToR) of the SoW as long as the role and ability of the CIE reviewer to complete the SoW deliverable in accordance with the ToRs and deliverable schedule are not adversely impacted. The SoW and ToRs cannot be changed once the peer review has begun.

Acceptance of Deliverables: Upon review and acceptance of the CIE independent peer review reports by the CIE Lead Coordinator, Regional Coordinator, and Steering Committee,

these reports shall be sent to the COTR for final approval as contract deliverables based on compliance with the SoW. As specified in the Schedule of Milestones and Deliverables, the CIE shall send via e-mail the contract deliverables (the CIE independent peer review reports) to the COTR (William Michaels, via William.Michaels@noaa.gov).

Applicable Performance Standards: The contract is successfully completed when the COTR provides final approval of the contract deliverables. The acceptance of the contract deliverables shall be based on three performance standards: (1) the CIE report shall have the format and content in accordance with Annex 1, (2) the CIE report shall address each ToR as specified in Annex 2, (3) the CIE reports shall be delivered in a timely manner as specified in the schedule of milestones and deliverables.

Distribution of Approved Deliverables: Upon notification of acceptance by the COTR, the CIE Lead Coordinator shall send via e-mail the final CIE reports in *.PDF format to the COTR. The COTR will distribute the approved CIE reports to the NMFS Project Contact and regional Center Director.

Support Personnel:

William Michaels, Program Manager, COTR
NMFS Office of Science and Technology
1315 East West Hwy, SSMC3, F/ST4, Silver Spring, MD 20910
William.Michaels@noaa.gov Phone: 301-713-2363 ext 136

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Roger W. Peretti, Executive Vice President
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Key Personnel:

Nancy Lo, **NMFS Project Contact**
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8604 La Jolla Shores Dr., La Jolla, CA 92037
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Dr. Russ Vetter, Director, FRD,
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Annex 1: Format and Contents of CIE Independent Peer Review Report

1. The CIE independent report shall be prefaced with an Executive Summary providing a concise summary of the findings and recommendations.

2. The main body of the reviewer report shall consist of a Background, Description of the Individual Reviewer's Role in the Review Activities, Summary of Findings for each ToR, and Conclusions and Recommendations in accordance with the ToRs.

   a. Reviewer should describe in their own words the review activities completed during the panel review meeting, including providing a detailed summary of findings, conclusions, and recommendations.

   b. Reviewer should discuss their independent views on each ToR even if these were consistent with those of other panelists, and especially where there were divergent views.

   c. Reviewer should elaborate on any points raised in the Summary Report that they feel might require further clarification.

   d. Reviewer shall provide a critique of the NMFS review process, including suggestions for improvements of both process and products.

   e. The CIE independent report shall be a stand-alone document for others to understand the proceedings and findings of the meeting, regardless of whether or not they read the summary report. The CIE independent report shall be an independent peer review of each ToRs, and shall not simply repeat the contents of the summary report.

3. The reviewer report shall include as separate appendices as follows:

   Appendix 1: Bibliography of materials provided for review
   Appendix 2: A copy of the CIE Statement of Work
   Appendix 3: Panel Membership or other pertinent information from the panel review meeting.

Annex 2: Terms of Reference for the Peer Review of the Pacific sardine stock assessment

The CIE reviewer is one of the four equal members of the STAR panel. The principal responsibilities of the STAR Panel are to review stock assessment data inputs, analytical models, and to provide complete STAR Panel reports.

Along with the entire STAR Panel, the CIE Reviewer's duties include:
1. Reviewing draft stock assessment and other pertinent information (e.g.; previous assessments and STAR Panel reports);
2. Working with STAT Teams to ensure assessments are reviewed as needed;
3. Documenting meeting discussions;
4. Reviewing summaries of stock status (prepared by STAT Teams) for inclusion in the Stock Assessment and Fishery Evaluation (SAFE) document;
5. Recommending alternative methods and/or modifications of proposed methods, as appropriate during the STAR Panel meeting, and;
6. The STAR Panel's terms of reference concern technical aspects of stock assessment work. The STAR Panel should strive for a risk neutral approach in its reports and deliberations.

The STAR Panel, including the CIE Reviewer, is responsible for determining if a stock assessment or technical analysis is sufficiently complete. It is their responsibility to identify assessments that cannot be reviewed or completed for any reason. The decision that an assessment is complete should be made by Panel consensus. If agreement cannot be reached, then the nature of the disagreement must be described in the Panels' and CIE Reviewer's reports.

The review solely concerns technical aspects of stock assessment. It is therefore important that the Panel strive for a risk neutral perspective in its reports and deliberations. Assessment results based on model scenarios that have a flawed technical basis, or are questionable on other grounds, should be identified by the Panel and excluded from the set upon which management advice is to be developed. The STAR Panel should comment on the degree to which the accepted model scenarios describe and quantify the major sources of uncertainty Confidence intervals of indices and model outputs, as well as other measures of uncertainty that could affect management decisions, should be provided in completed stock assessments and the reports prepared by STAR Panels.

Recommendations and requests to the STAT Team for additional or revised analyses must be clear, explicit, and in writing. A written summary of discussion on significant technical points and lists of all STAR Panel recommendations and requests to the STAT Team are required in the STAR Panel's report. This should be completed (at least in draft form) prior to the end of the meeting. It is the chair and Panel's responsibility to carry out any follow-up review of work that is required.

DRAFT AGENDA: CPS STAR PANEL

Tuesday 4 October

08h30 Call to Order and Administrative Matters
Introductions Punt
Facilities, e-mail, network, etc. Lo
Work plan and Terms of Reference Griffin
Report Outline and Appointment of Rapporteurs Punt
09h00 Pacific Sardine assessment presentation Hill
10h00 Break
10h30 Pacific Sardine assessment presentation Hill
11h30 Acoustic and trawl survey Zwolinski
12h30 Bayesian estimates of spawning fraction Lo
12h30 Lunch
13h30 Pacific Sardine assessment presentation(continue) Hill
14h30 Panel discussion and analysis requests Panel
15h00 Break
15h30 Public comments and general issues
17h00 Adjourn

Wednesday and Thursday 5-6 October

08h00. Assessment Team Responses Hill
10h30 Break
11h00. Discussion and STAR Panel requests Panel
12h30 Lunch
13h30 Report drafting Panel
15h00 Break
15h30 Assessment Team Responses Hill
16h30 Discussion and STAR Panel requests
17h00 Adjourn

Friday, 7 October, 2011

08h00 Assessment Team Responses Hill
09h00 Finalize STAR Panel Report Panel
10h30 Break
11h00 Finalize STAR Panel Report Panel
13h00 Adjourn

Annex 4: STAR Panel Summary Report (Template)

- Names and affiliations of STAR Panel members
- List of analyses requested by the STAR Panel, the rationale for each request, and a brief summary the STAT responses to each request
- Comments on the technical merits and/or deficiencies in the assessment and recommendations for remedies
- Explanation of areas of disagreement regarding STAR Panel recommendations
  - Among STAR Panel members (including concerns raised by the CPSMT and CPSAS representatives)
  - Between the STAR Panel and STAT Team
- Unresolved problems and major uncertainties, e.g., any special issues that complicate scientific assessment, questions about the best model scenario, etc.
- Management, data or fishery issues raised by the public and CPSMT and CPSAS representatives during the STAR Panel
- Prioritized recommendations for future research and data collection

Appendix 3. STAR panel attendees

STAR Panel Members

André Punt (Chair)	Scientific and Statistical Committee (SSC), Univ of Washington
Ray Conser	SSC, Southwest Fisheries Science Center
Larry Jacobson	External Reviewer, Northeast Fisheries Science Center
Chris Francis	Center for Independent Experts (CIE)

Pacific Fishery Management Council (Council) Representatives

Lorna Wargo	Coastal Pelagic Species Management Team (CPSMT)
Mike Okoniewski	Coastal Pelagic Species Advisory Subpanel (CPSAS)
Kerry Griffin	Council Staff

Pacific Sardine Stock Assessment Team

Kevin Hill	NOAA / SWFSC
Paul Crone	NOAA / SWFSC
Nancy Lo	NOAA / SWFSC
Beverly Macewicz	NOAA / SWFSC
Emmanis Dorval	NOAA / SWFSC
Jennifer McDaniel	NOAA / SWFSC
Yuhong Gu	NOAA / NWFSC

Acoustic-Trawl Survey Team

David Demer	NMFS, SWFSC
Juan Zwolinski	NMFS, SWFSC

Aerial Survey Team

Tom Jagielo	Tom Jagielo Consulting

Other attendees

Greg Krutzikowsky	ODFW
Steve Marx	Pew Charitable Trusts
Piera Carpi	UMass, Dartmouth
Sandy McFarlane	Canadian DFO & Canadian Pacific Sardine Association
Linnea Flostrand	Canadian DFO
Bob Seidel	Commercial fishing
Kirk Lynn	CDFG
Jerry Thon	Northwest Aerial Sardine Survey (NWSS)
Dale Sweetnam	SWFSC
Erin Reed	SWFSC
Sam Herrick	SWFSC
Diane Pleschner-Steele	CA Wetfish Producers Association
Ryan Howe	NWSS
Richard Carroll	Ocean Gold Seafood
Ed Weber	SWFSC
David Haworth	Commercial fishing
Fabio Campanella	SWFSC
Josh Lindsay	NMFS SWR
Christina Show	SWFSC
Russ Vetter	SWFSC
Kristen Koch	SWFSC